AD NO. _____
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-8740

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 127

SITE LOCATION:
ABERDEEN PROVING GROUND

DEMONSTRATOR:
NAVAL RESEARCH LABORATORIES
CODE 6110 NAVAL RESEARCH LABORATORIES
WASHINGTON, DC 20375-5342

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

JANUARY 2004

Prepared for:
U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MD 21010-5401

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14. ABSTRACT
This scoring record documents the efforts of Naval Research Laboratories to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Blind Grid. The firing record was coordinated by Larry Overbay and by the Standardized UXO Technology Demonstration Site Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (AEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time, and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating

characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e., that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-, 40-, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Reacquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm Heat Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb

JPG = Jefferson Proving Ground.

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: Herb Nelson
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Address: Naval Research Laboratory
Code 6110
Naval Research Laboratory
Washington, DC 20375-5342

2.1.2 System Description (Provided by Demonstrator)

The Multi-Sensor Towed Array Detection System (MTADS) GEM array is comprised of three 96-cm diameter GEM3 frequency-domain electromagnetic interference (EMI) sensors mounted in a triangular array (fig. 1). The array is mounted on a 3.5-meter long platform that is pulled by the MTADS tow vehicle (fig. 2). The sensor transmit electronics and signal analog to digitals (A/Ds) are located on the tow platform just in front of the sensor coils, the remaining sensor electronics are rack mounted in the tow vehicle. Also mounted on the tow platform are three Global Positioning System (GPS) antennae and an International Measurement Unit (IMU).

Each of the three sensors in the array sequentially transmits a composite waveform made up of ten frequencies logarithmically spaced from 30 Hz to just over 20 kHz for one base period (1/30 s). Thus, only one complete cycle of the 30 Hz frequency is transmitted while many thousands of cycles of the highest frequency are transmitted. The transmit current drives both a transmit coil and a counterwound bucking coil. This serves to set up a "magnetic cavity" inside the bucking coil in which is placed a receive coil. The current induced in this receive coil by the induced fields in buried metal targets is detected, digitized, and frequency resolved during the two subsequent base periods while the other array sensors are transmitting. The detected signal is compared to the transmitted current and reported relative to the transmit current (parts per million (ppm)) as both an in-phase and quadrature component.

These twenty measured responses (in-phase and quadrature at ten frequencies) make up the "EMI Spectrum" of the buried targets. These spectra can be analyzed by fitting to empirical functions, comparing against known library spectra, or fitting to target response coefficients. All three of these analysis methodologies will be applied to the data collected in this demonstration and their results compared.

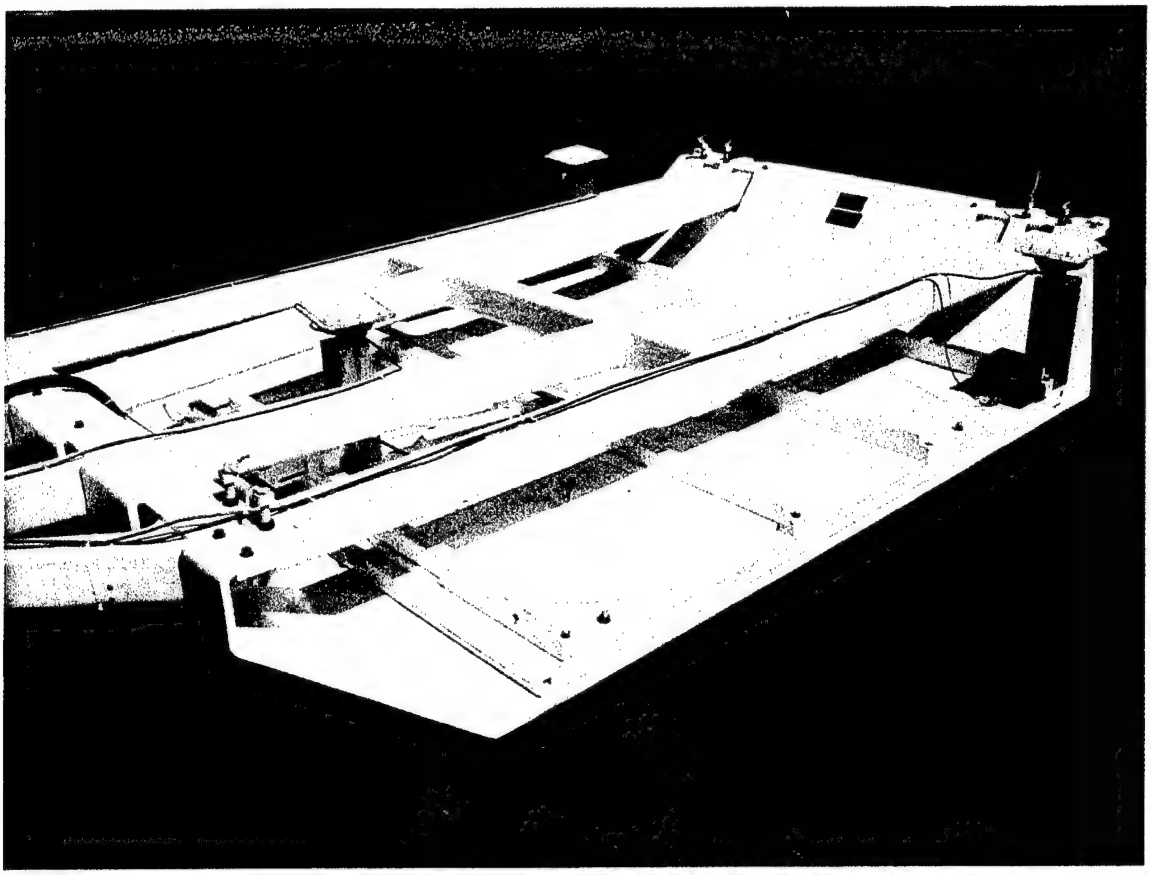

Figure 1. Demonstrator's system (MTADS GEM array on tow platform showing three sensors, three GPS antennae, and the IMU).

Figure 2. Demonstrator's system (MTADS GEM array pulled by the MTADS tow vehicle).

2.1.3 Data Processing Description (Provided by Demonstrator)

The MTADS GEM array consists of three, 96-cm diameter sensors arranged in a triangle. It is pulled by the MTADS tow vehicle over the site at approximately 3 miles per hour. Lane spacing is the width of the MTADS tow vehicle, approximately 1.75 meters. Data are recorded from the array at approximately 9.7 Hz. This results in a down-track sampling interval of ~15 cm and a cross track sampling interval of 50 cm. For the measurements at APG, data will be recorded while traversing the test field in two orthogonal directions (roughly North-South and East-West). As part of the analysis, the extra classification performance (if any) that results from these extra data will be determined.

Individual sensors in the array are located using a three-receiver real-time kinematic (RTK) GPS system as shown in Figure 1. From this set of receivers, the position of the master antenna is recorded at 20 Hz, and the vectors to the other two antennae are recorded at 10 Hz. All positions are recorded at full RTK precision, ~2-5 cm. In addition, the output of a full 6-axis IMU at 80 Hz is recorded to give complimentary information on platform pitch and roll. All sensor readings are referenced to the GPS PostPostscriptum (1-PPS) output so full advantage could be taken of the precision of the GPS measurements.

The individual data streams into the data acquisition computer, running a custom variant of the WinGEM program called WinGEMArray, are each recorded in a separate file. These individual data files, which share a root name that corresponds to the data and time the survey was initiated, include three sensor data files, four GPS files (one containing the National Maritime Electronics Association (NMEA) GGK sentences corresponding to the position of the master antenna and an automatic volume recognition (AVR) sentence giving one of the vectors to the secondary antennae, another containing the second AVR sentence, a third containing the universal time coordinated (UTC) time tag, and the fourth containing the computer-time stamped arrival of the GPS PPS), and one file for the IMU output. The sensor and GPS files are ASCII format and the IMU file mirrors the packed binary output of the IMU.

All these files are transferred to the data analysis system using ZIP-250 disks. They are then checked for data quality, leveled, and the position information is applied to the sensor files. The result is a sequence of positioned measurements of the measured response at ten frequencies. This latter file is referred to as raw data.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. These submitted data are not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (Provided by Demonstrator)

To ensure adequate system performance, three items need to be checked daily. They are: individual sensor response, timing accuracy of the sensor measurements, and reliability of GPS positions. Before beginning survey work each day, the performance of each of the three sensors in the array is measured (after a 5-minute warm-up) by presenting a ferrite rod and a standard

sphere as targets. These test targets are mounted on a short, wooden block that is placed directly on the sensor coils. The resulting frequency-dependent signals are checked against standard values.

System timing accuracy is checked by making a back-and-forth traverse over a linear target at the beginning and end of each 1-hour survey file. This target can either be a steel wire stretched between stakes or a small diameter (1/2 in.) copper pipe placed on the ground adjacent to the survey area. ATC on-site personnel will determine the best target.

The data acquisition system gives the vehicle operator a continuous reading of the quality of the GPS fix. The standard procedure is to only take data with a GPS fix quality of 3 (RTK fixed) or 2 (RTK float) and a precision dilution of precision (PDOP) of 4 or less. Before arriving at the site each day, standard GPS planning software is used to calculate the number of satellites that will be visible to the receivers and the PDOP achievable minute-by-minute throughout the day. This allows GPS planning during periods of poor satellite availability and keeps inadvertent data, that would have to be discarded, from being recorded. Another important feature GPS planning provides is the ability to take into account areas of restricted sky view (such as the tree line at one edge of the APG site). Past experience shows there is usually a brief period each day, on the order of 20 to 30 minutes, when good fixes can be obtained in even the most difficult environments. With planning, the system can be poised by the tree line ready to take data when the appropriate satellite alignment occurs.

Overview of QA. At the end of each 1-hour survey session, all survey data is transferred to the field data analyst for preliminary data quality checks. This process involves plotting the actual survey path as logged in the GPS files (color-coded by GPS fix quality) to ensure that GPS data of sufficient quality were obtained during the survey. Following this, the individual sensor files are examined for completeness and consistency. It is at this stage that sensor malfunctions, drifts, etc., are flagged and reported to the field crew for correction. The final objective for the field analyst is to calculate a position for each sensor reading and apply it to the reading. The mapped data files are then ready for analysis either in the field, or at a later time.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MS Word files at http://aec.army.mil/usaec/technology/uxo03.html.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area of APG. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of APG in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consist of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May of 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77 percent) of the soil samples had a measured water content between 15- and 30-percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to http://aec.army.mil/usaec/technology/uxo-soils.pdf on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains 14 standard ordnance items buried in six positions at various angles and depths to allow demonstrator equipment calibration.
Blind Grid	Contains 400 grid cells in a 0.2-hectare (0.5 acre) site. The center of each grid cell contains ordnance, clutter or nothing.

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SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (24 to 25 September 2003, 2 and 6 October 2003)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	1.48
Blind Grid	1.62

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An ATC weather station located approximately 2 miles west of the test site was used to record average temperature and precipitation on an hourly basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 through 1700 hours while the precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 2003	Average Temperature, °F	Total Daily Precipitation, in.
September 24	68.3	0.00
September 25	72.6	0.04
October 2	53.2	0.00
October 6	57.3	0.00

3.3.2 Field Conditions

The Naval Research Laboratory (NRL) surveyed the blind grid with the towed GEM array on 24 September and 2 October 2003. The Blind Grid area was muddy due to rain events which occurred before testing.

3.3.3 Soil Moisture

Soil moisture logs are included in Appendix C. Three soil probes were placed at various locations of the site to capture soil moisture data: open field, open field lowland (wet) and open field scenario No. 1 wooded area. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil layers (0 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in. and 36 to 48 in.) from each probe.

The soil moisture data collected are summarized in Table 5. The average moisture content was calculated by averaging the morning and afternoon measurements for each layer of each probe for the duration of the field operations in the Blind Grid.

TABLE 5. SOIL MOISTURE DATA SUMMARY

Layer, in.	Average Moisture Content, %	Standard Deviation, %
BLIND GRID SOIL PROBE		
0 to 6	3.40	1.28
6 to 12	17.67	7.84
12 to 24	36.20	16.67
24 to 36	36.56	16.38
36 to 48	37.80	16.49
CALIBRATION LANES SOIL PROBE		
0 to 6	38.73	1.33
6 to 12	37.77	0.12
12 to 24	7.90	0.26
24 to 36	4.73	0.32
36 to 48	4.73	0.23

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and break down. The four-person crew took 3 hours and 20 minutes to perform the initial setup and mobilization. Daily equipment preparation totaled 1 hour and 10 minutes while end of day equipment break down over the course of the demonstration lasted 2 hours and 7 minutes.

3.4.2 Calibration

The demonstrator spent 1 hour and 29 minutes collecting data in the calibration lanes. NRL also spent a total of 25 minutes calibrating their equipment during the survey of the Blind Grid using a ferrite rod.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered nonchargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are not discussed either.

3.4.3.1 Equipment/data checks, maintenance. Equipment/data checks and maintenance activities accounted for 45 minutes of site usage time. These activities included changing out batteries and routine data checks to ensure data were being properly recorded/collected.

3.4.3.2 Equipment failure or repair. One failure occurred in the blind grid. A 12-minute delay occurred when the vehicle got stuck in the blind grid.

3.4.3.3 Weather. No delays occurred due to weather.

3.4.4 Data Collection

The demonstrator spent 1 hour and 25 minutes collecting data in the blind grid. This time excludes break/lunches and downtimes described in section 3.4.3.

3.4.5 Demobilization

The demobilization time for the towed system took 1 hour. On 6 October 2003, NRL field crew packed up all equipment and permanently left the site.

3.5 PROCESSING TIME

NRL submitted the raw data from demonstration activities on the last day of the demonstration, as required. The scoring submission data were also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Herb Nelson, NRL
Dan Steinhurst, NOVA Research, Inc.
Glenn Harbaugh, NOVA Research, Inc.
Nagi Khadr, AETC, Inc.

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

NRL started surveying the blind grid in the northeast portion and surveyed in an east/west direction. One lane was surveyed and then the demonstrator returned to the beginning of the next lane (example: 1A, 1B, 1C then 2A, 2B, 2C) until completion.

3.8 SUMMARY OF DAILY LOGS

No significant events occurred during the demonstration. NRL was scheduled to survey the Open Field during this site visit. Inclement weather and rain-saturated conditions caused the field crew to cancel the demonstration in the Open Field. The Daily Logs found in Appendix D contains a detailed description of field operations including partial coverage of the open field.

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SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 3 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 4 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

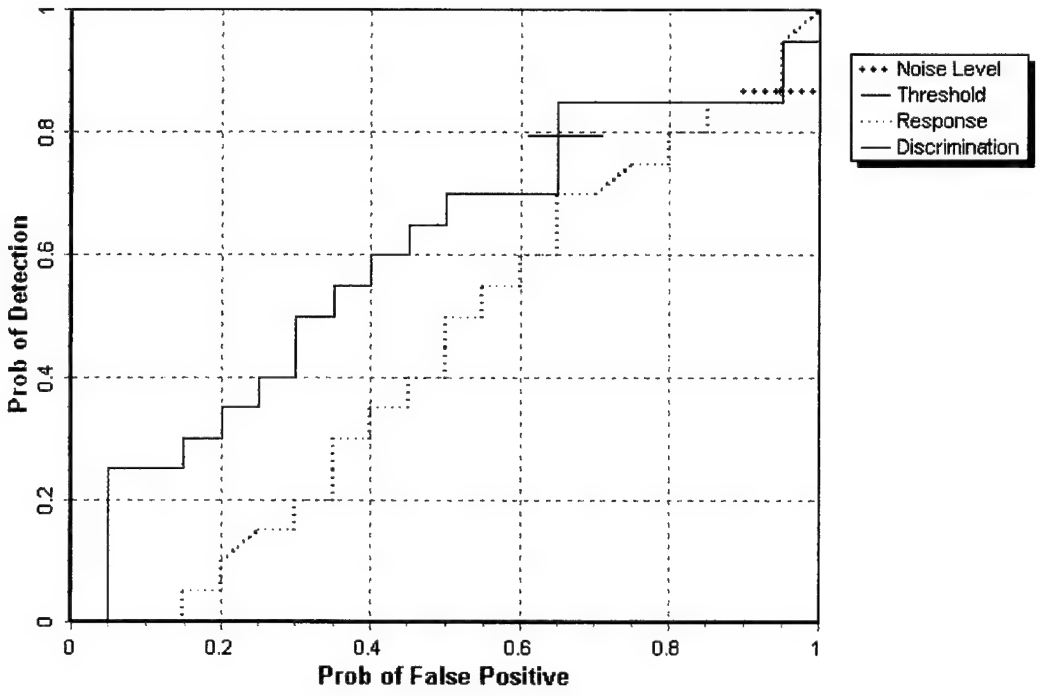

Figure 3. Blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

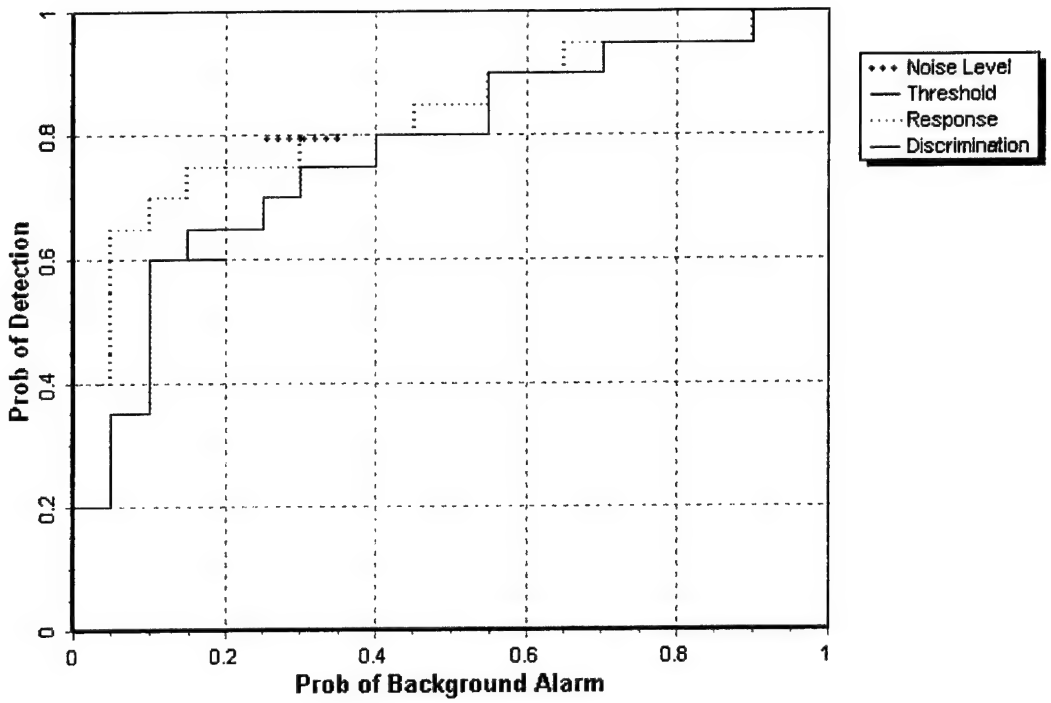

Figure 4. Blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 5 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20 mm are scored. Figure 6 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

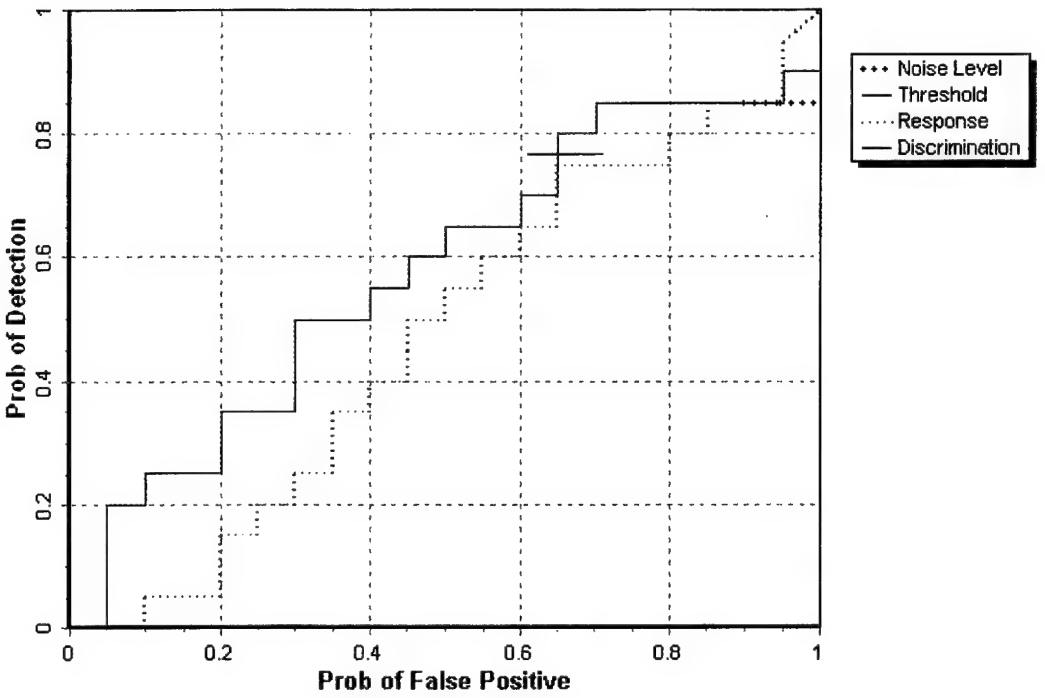

Figure 5. Blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

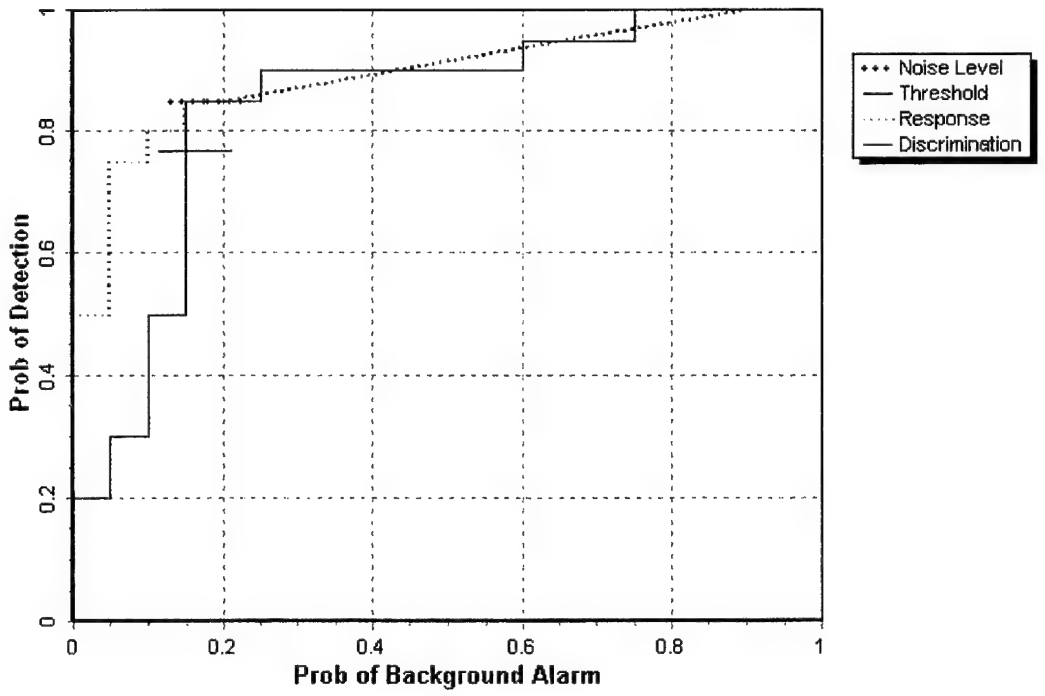

Figure 6. Blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented in Table 6. (For cost results, see section 5.) Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. (See app A for size definitions.) The results are relative to the number of ordnances emplaced. Depth is measured from the closest point of anomaly to the ground surface.

The RESPONSE STAGE results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the DISCRIMINATION STAGE are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 6 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 6. SUMMARY OF BLIND GRID RESULTS

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.85	0.90	0.85	1.00	0.75	0.80	1.00	0.95	0.00
P_d Low 90% Conf	0.81	0.80	0.73	0.91	0.61	0.55	0.95	0.88	0.00
P_{fp}	0.95	-	-	-	-	-	0.95	0.95	1.00
P_{fp} Low 90% Conf	0.90	-	-	-	-	-	0.89	0.85	0.63
P_{ba}	0.20	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.80	0.80	0.80	0.95	0.60	0.70	0.90	0.90	0.00
P_d Low 90% Conf	0.73	0.69	0.69	0.88	0.48	0.45	0.82	0.80	0.00
P_{fp}	0.65	-	-	-	-	-	0.55	0.75	0.80
P_{fp} Low 90% Conf	0.59	-	-	-	-	-	0.47	0.63	0.42
P_{ba}	0.15	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.40.
Recommended Discrimination Stage Threshold: 100.00.

Note: The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 7.

TABLE 7. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.92	0.30	0.08
With No Loss of P_d	1.00	0.06	0.00

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8). Correct type examples include "20-mm projectile, 105-mm HEAT Projectile, and 2.75-in. Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 8. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	% Correct
Small	65.0
Medium	57.9
Large	71.4
Overall	63.6

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 9. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the Blind Grid, only depth errors are calculated, since (x, y) positions are known to be the centers of each grid square.

TABLE 9. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Depth	-0.06	0.20

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on-site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 10. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 10. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
INITIAL SETUP				
Supervisor	1	$95.00	3.33	$316.35
Data Analyst	1	57.00	3.33	189.81
Field Support	2	28.50	6.66	189.81
Subtotal				**$695.97**
CALIBRATION				
Supervisor	1	$95.00	1.9	$180.50
Data Analyst	1	57.00	1.9	108.30
Field Support	2	28.50	3.8	108.30
Subtotal				**$397.10**
SITE SURVEY				
Supervisor	1	$95.00	1.62	$153.90
Data Analyst	1	57.00	1.62	92.34
Field Support	2	28.50	3.24	92.34
Subtotal				**$338.58**

See notes at end of table.

TABLE 10 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
DEMOBILIZATION				
Supervisor	1	$95.00	1.0	$95.00
Data Analyst	1	57.00	1.0	57.00
Field Support	2	28.50	2.0	57.00
Subtotal				**$209.00**
Total				**$1,640.65**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.

Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO DATE

No comparisons to date.

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SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., nonordnance item) buried by the government at a specified location in the test site.

R_{halo}: A predetermined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meter in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meter in length. When ordnance items are longer than 0.6 meter, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75 inch Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500-lb bomb).

Shallow: Items buried less than 0.3 meter below ground surface.

Medium: Items buried greater than or equal to 0.3 meter and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/ (No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to nonordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d versus P_{fp} and P_d versus BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure A-1 shows how P_d versus P_{fp} and P_d versus BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

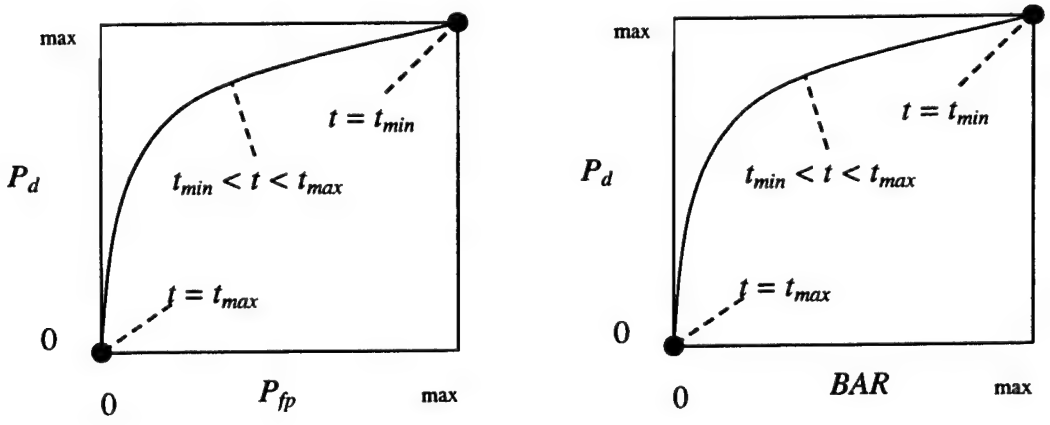

Figure A-1. ROC curves for open-field testing. Each curve applies to both the response and discrimination stages.

[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a predetermined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an Open Field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$ Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False-Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

Blind Grid: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$
Open Field: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

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APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
9/24/2003	01:00	59.0	60.6	57.7	88.90	0.00
9/24/2003	02:00	58.3	59.1	57.6	94.40	0.00
9/24/2003	03:00	57.8	58.2	57.1	87.10	0.00
9/24/2003	04:00	56.7	58.2	55.8	92.80	0.00
9/24/2003	05:00	57.4	58.0	56.7	92.40	0.00
9/24/2003	06:00	57.9	58.6	57.3	86.10	0.00
9/24/2003	07:00	59.8	61.8	58.1	81.40	0.00
9/24/2003	08:00	62.7	64.0	61.3	77.56	0.00
9/24/2003	09:00	64.4	65.8	63.4	76.29	0.00
9/24/2003	10:00	66.9	68.7	65.3	70.26	0.00
9/24/2003	11:00	69.3	70.6	68.1	59.38	0.00
9/24/2003	12:00	70.0	70.7	69.5	55.20	0.00
9/24/2003	13:00	71.5	73.2	69.7	56.52	0.00
9/24/2003	14:00	72.1	72.7	71.4	55.08	0.00
9/24/2003	15:00	72.1	72.7	71.3	50.98	0.00
9/24/2003	16:00	71.5	72.0	71.1	48.35	0.00
9/24/2003	17:00	71.1	71.7	70.0	50.83	0.00
9/24/2003	18:00	67.8	70.2	65.6	57.91	0.00
9/24/2003	19:00	64.6	65.9	63.4	67.42	0.00
9/24/2003	20:00	64.3	65.4	63.5	73.73	0.00
9/24/2003	21:00	63.8	65.2	62.8	78.67	0.00
9/24/2003	22:00	64.5	65.5	62.7	79.89	0.00
9/24/2003	23:00	62.2	63.1	61.4	84.10	0.00
9/25/2003	00:00	62.2	63.2	60.6	85.50	0.00
9/25/2003	01:00	61.5	62.3	60.8	84.80	0.00
9/25/2003	02:00	62.5	63.1	61.9	87.70	0.00
9/25/2003	03:00	62.4	63.1	61.7	91.40	0.00
9/25/2003	04:00	62.3	62.8	61.7	93.90	0.00
9/25/2003	05:00	62.8	63.2	62.2	95.20	0.00
9/25/2003	06:00	62.5	63.2	61.7	96.90	0.00
9/25/2003	07:00	62.8	64.7	61.3	98.00	0.00
9/25/2003	08:00	65.6	66.5	64.4	94.70	0.00
9/25/2003	09:00	68.6	70.5	66.2	89.10	0.00
9/25/2003	10:00	71.3	72.4	70.0	80.50	0.00
9/25/2003	11:00	72.5	73.4	71.0	71.61	0.00
9/25/2003	12:00	73.9	74.9	72.6	69.14	0.00
9/25/2003	13:00	75.9	77.1	74.3	64.20	0.00
9/25/2003	14:00	77.2	78.0	76.5	62.31	0.00
9/25/2003	15:00	77.9	78.4	77.3	62.12	0.00
9/25/2003	16:00	77.5	78.4	75.5	62.43	0.00
9/25/2003	17:00	75.6	76.7	74.2	67.93	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
9/25/2003	18:00	72.5	74.5	70.7	75.73	0.00
9/25/2003	19:00	70.7	71.7	69.1	80.20	0.00
9/25/2003	20:00	70.1	71.3	68.5	82.10	0.00
9/25/2003	21:00	70.0	70.9	69.2	87.40	0.00
9/25/2003	22:00	68.9	69.5	68.1	85.40	0.01
9/25/2003	23:00	66.9	68.3	66.3	91.20	0.03
10/2/2003	00:00	51.2	52.2	50.5	85.50	0.00
10/2/2003	01:00	50.8	51.5	50.3	84.10	0.00
10/2/2003	02:00	51.1	52.0	50.1	78.56	0.00
10/2/2003	03:00	49.0	51.1	47.8	77.85	0.00
10/2/2003	04:00	47.8	48.8	46.8	79.08	0.00
10/2/2003	05:00	45.7	47.2	43.7	85.40	0.00
10/2/2003	06:00	44.5	45.7	43.5	87.90	0.00
10/2/2003	07:00	46.4	48.8	43.9	84.60	0.00
10/2/2003	08:00	48.7	50.4	47.2	78.77	0.00
10/2/2003	09:00	50.5	53.2	49.0	73.78	0.00
10/2/2003	10:00	54.0	56.1	52.7	64.64	0.00
10/2/2003	11:00	55.4	56.8	54.1	56.44	0.00
10/2/2003	12:00	56.0	57.7	54.4	45.55	0.00
10/2/2003	13:00	54.7	55.5	53.3	40.33	0.00
10/2/2003	14:00	54.8	56.4	53.5	38.49	0.00
10/2/2003	15:00	55.3	56.2	54.3	34.82	0.00
10/2/2003	16:00	55.1	56.2	54.5	35.37	0.00
10/2/2003	17:00	54.4	55.2	53.7	35.86	0.00
10/2/2003	18:00	52.3	54.0	50.5	41.73	0.00
10/2/2003	19:00	49.7	50.6	48.6	48.01	0.00
10/2/2003	20:00	48.6	49.6	47.4	52.65	0.00
10/2/2003	21:00	48.8	49.3	48.2	56.72	0.00
10/2/2003	22:00	47.9	48.6	47.0	61.29	0.00
10/2/2003	23:00	46.6	47.6	45.6	66.45	0.00
10/6/2003	00:00	50.9	51.5	50.4	77.19	0.00
10/6/2003	01:00	50.5	51.0	50.1	78.14	0.00
10/6/2003	02:00	50.4	50.9	49.9	78.91	0.00
10/6/2003	03:00	49.8	50.3	49.3	79.68	0.00
10/6/2003	04:00	49.6	49.8	49.3	78.47	0.00
10/6/2003	05:00	49.4	49.9	49.0	83.10	0.00
10/6/2003	06:00	49.0	49.6	48.5	82.80	0.00
10/6/2003	07:00	48.4	48.8	47.9	85.40	0.00
10/6/2003	08:00	49.4	51.1	48.1	79.32	0.00
10/6/2003	09:00	52.2	54.2	50.8	73.15	0.00
10/6/2003	10:00	55.4	57.0	53.6	60.08	0.00
10/6/2003	11:00	58.0	59.2	56.5	51.05	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
10/6/2003	12:00	59.3	59.9	58.5	48.04	0.00
10/6/2003	13:00	59.9	61.7	59.2	50.86	0.00
10/6/2003	14:00	61.8	63.0	60.6	48.14	0.00
10/6/2003	15:00	62.8	64.0	62.2	46.59	0.00
10/6/2003	16:00	61.8	62.8	60.8	46.48	0.00
10/6/2003	17:00	61.3	62.4	60.0	48.58	0.00
10/6/2003	18:00	59.6	61.7	58.3	54.91	0.00
10/6/2003	19:00	58.5	59.3	57.3	57.60	0.00
10/6/2003	20:00	56.3	57.6	55.3	67.84	0.00
10/6/2003	21:00	54.8	55.7	54.1	65.11	0.00
10/6/2003	22:00	54.0	54.6	53.3	66.87	0.00
10/6/2003	23:00	53.5	54.0	52.7	66.08	0.00

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APPENDIX C. SOIL MOISTURE

Daily Soil Moisture Logs

Demonstrator: Naval Research Laboratory.
Date: 24 September 2003.
Times: 0900 hours (AM), 1330 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Wooded Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Open Area	0 to 6	29.0	28.9
	6 to 12	0.5	0.7
	12 to 24	25.0	24.7
	24 to 36	33.4	33.5
	36 to 48	52.6	52.9
Calibration Lanes	0 to 6	39.5	39.5
	6 to 12	37.7	37.9
	12 to 24	7.8	7.7
	24 to 36	4.5	4.6
	36 to 48	4.6	4.6
Blind Grid/Moguls	0 to 6	3.6	3.8
	6 to 12	18.0	17.9
	12 to 24	35.2	35.0
	24 to 36	35.2	35.4
	36 to 48	36.4	36.8

Daily Soil Moisture Logs

Demonstrator: Naval Research Laboratory.
Date: 25 September 2003.
Times: 0900 hours (AM), 1330 hours (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Wooded Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Open Area	0 to 6	29.2	28.7
	6 to 12	0.6	0.4
	12 to 24	24.8	25.2
	24 to 36	33.8	34.1
	36 to 48	52.7	52.5
Calibration Lanes	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Blind Grid/Moguls	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA

Daily Soil Moisture Logs

Demonstrator: Naval Research Laboratory.
Date: 2 October 2003.
Times: 0930 hours (AM), (Demonstration complete) (PM).

Probe Location	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Wooded Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Open Area	0 to 6	NA	NA
	6 to 12	NA	NA
	12 to 24	NA	NA
	24 to 36	NA	NA
	36 to 48	NA	NA
Calibration Lanes	0 to 6	37.2	NA
	6 to 12	37.7	NA
	12 to 24	8.2	NA
	24 to 36	5.1	NA
	36 to 48	5.0	NA
Blind Grid/Moguls	0 to 6	2.8	NA
	6 to 12	17.1	NA
	12 to 24	38.4	NA
	24 to 36	39.1	NA
	36 to 48	40.2	NA

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Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
9/24/2003	4	CALIBRATION LANE	0830	1150	200	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1150	1151	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1151	1152	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1152	1153	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1153	1154	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1154	1155	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1155	1156	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1156	1157	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1157	1158	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1158	1159	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1159	1200	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1200	1201	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1201	1202	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1202	1203	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1203	1204	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1204	1205	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1205	1217	12	DOWNTIME MAINTENANCE CHECK	DATA CHECK	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1217	1218	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1218	1219	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1219	1220	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1220	1221	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1221	1222	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1222	1223	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1223	1224	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
9/24/2003	4	BLIND GRID	1224	1225	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1225	1237	12	EQUIPMENT FAILURE	VEHICLE STUCK	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1237	1238	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1238	1239	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1239	1240	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1240	1241	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1241	1242	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1242	1243	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1243	1244	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1244	1245	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1245	1246	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1246	1247	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1247	1248	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1248	1249	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1249	1250	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1250	1251	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1251	1252	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1252	1253	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1253	1254	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1254	1255	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1255	1256	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1256	1257	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1257	1258	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1258	1259	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	BLIND GRID	1259	1300	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	OPEN FIELD	1300	1301	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
9/24/2003	4	CALIBRATION LANE	1301	1302	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/24/2003	4	OPEN FIELD	1303	1304	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1304	1305	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1305	1306	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1306	1307	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1307	1308	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1308	1309	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1309	1310	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1310	1311	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1311	1312	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1312	1313	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1313	1314	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1314	1315	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003		CALIBRATION LANE	1315	1330	15	CALIBRATE	CALIBRATE USING IRON ROD				
9/24/2003		CALIBRATION LANE	1330	1350	20	BREAK/LUNCH	BREAK/LUNCH				
9/24/2003	4	CALIBRATION LANE	1350	1351	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1351	1352	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1352	1353	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1353	1354	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1354	1355	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1355	1356	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1356	1357	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1357	1358	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1358	1359	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1359	1400	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1400	1401	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1401	1402	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/24/2003	4	CALIBRATION LANE	1402	1403	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1403	1404	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1404	1405	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1405	1406	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1406	1407	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1407	1408	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1408	1409	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1409	1410	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1410	1411	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1411	1412	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1412	1413	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1413	1414	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1414	1415	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1415	1420	5	DOWNTIME MAINTENANCE CHECK	EQUIPMENT CHECK	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1420	1421	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1421	1422	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1422	1423	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1423	1424	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1424	1425	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1425	1426	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1426	1427	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1427	1428	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1428	1429	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1429	1430	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1430	1431	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1431	1432	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/24/2003	4	CALIBRATION LANE	1432	1433	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1433	1434	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1434	1435	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1435	1436	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1436	1437	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1437	1438	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1438	1439	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1439	1440	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1440	1441	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1441	1442	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1442	1443	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1443	1444	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1444	1445	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1445	1446	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1446	1447	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1447	1448	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1448	1449	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1449	1450	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1450	1451	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1451	1452	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1452	1453	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1453	1454	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1454	1455	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1455	1456	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1456	1457	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1457	1458	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1458	1459	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/24/2003	4	CALIBRATION LANE	1459	1500	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1500	1501	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1501	1502	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1502	1503	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1503	1504	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1504	1505	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1505	1506	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1506	1507	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1507	1508	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1508	1509	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1509	1510	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1510	1511	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1511	1512	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1512	1545	33	DOWNTIME MAINTENANCE CHECK	DATA CHECK	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1545	1546	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1546	1547	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1547	1548	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1548	1549	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1549	1550	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1550	1551	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1551	1552	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1552	1553	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1553	1554	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1554	1555	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1555	1556	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1556	1557	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/24/2003	4	CALIBRATION LANE	1557	1558	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1558	1559	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1559	1600	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1600	1601	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1601	1602	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1602	1603	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1603	1604	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1604	1605	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1605	1606	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	CALIBRATION LANE	1606	1607	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	BLIND GRID	1607	1608	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/24/2003	4	OPEN FIELD	1608	1650	42	DAILY START STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	0800	0830	30	DAILY START STOP	EQUIPMENT SET UP, BEGIN DAILY OPERATIONS	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	0830	0850	20	CALIBRATE	CALIBRATE USING IRON ROD	CALIBRATE USING IRON ROD	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	0850	0950	60	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	0950	1020	30	DOWNTIME MAINTENANCE CHECK	DATA CHECK	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1020	1110	50	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1110	1130	20	EQUIPMENT FAILURE	VEHICLE STUCK	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1130	1145	15	CALIBRATE	CALIBRATE USING IRON ROD	CALIBRATE USING IRON ROD	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1145	1205	20	DOWNTIME MAINTENANCE CHECK	TIGHTEN BOLTS ON VEHICLE	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1205	1230	25	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
9/25/2003	4	OPEN FIELD	1230	1300	30	BREAK/LUNCH	BREAK/LUNCH	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1300	1330	30	EQUIPMENT FAILURE	VEHICLE STUCK	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1330	1410	40	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
9/25/2003	4	OPEN FIELD	1410	1510	60	DAILY START STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0830	0940	70	DAILY START STOP	EQUIPMENT SET UP, BEGIN DAILY OPERATIONS	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0940	0945	5	CALIBRATE	CALIBRATE USING IRON ROD	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0945	0946	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0946	0947	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0947	0948	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0948	0949	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0949	0950	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0950	0951	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0951	0952	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0952	0953	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0953	0954	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0954	0955	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0955	0956	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0956	0957	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0957	0958	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	0958	0959	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	0959	1000	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1000	1001	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/2/2003	3	CALIBRATION LANE	1001	1002	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1002	1003	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1003	1004	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1004	1005	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1005	1006	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1006	1007	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1007	1008	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1008	1009	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1009	1010	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1010	1011	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1011	1012	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1012	1013	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1013	1014	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1014	1015	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1015	1016	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1016	1017	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1017	1018	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1018	1019	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1019	1020	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1020	1021	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1021	1022	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1022	1023	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1023	1024	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1024	1025	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/2/2003	3	CALIBRATION LANE	1025	1026	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1026	1027	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1027	1028	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1028	1029	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1029	1030	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1030	1031	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1031	1032	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1032	1033	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1033	1034	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1034	1035	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1035	1105	30	EQUIPMENT FAILURE	NOT GETTING A SATELLITE CONNECTION	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1105	1106	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1106	1107	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1107	1108	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1108	1109	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1109	1110	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1110	1111	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1111	1112	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1112	1113	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1113	1114	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1114	1115	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1115	1116	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1116	1117	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions
10/2/2003	3	CALIBRATION LANE	1117	1118	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	BLIND GRID	1118	1119	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1119	1120	1	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1120	1125	5	CALIBRATE	CALIBRATE USING IRON ROD	GPS	NA	LINEAR	SUNNY
10/2/2003	3	CALIBRATION LANE	1125	1250	85	DAILY START STOP	EQUIPMENT BREAKDOWN END OF DAILY OPERATIONS	GPS	NA	LINEAR	SUNNY
10/6/2003	3	CALIBRATION LANE	0945	1045	60	DEMOBILIZATION	DEMOBILIZATION	GPS	NA	LINEAR	SUNNY

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APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

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APPENDIX F. ABBREVIATIONS

1-PPS	=	PostPostscriptum
A/D	=	analog to digital
AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
AVR	=	automatic volume recognition
CAD	=	computer-aided design
DGPS	=	differential Global Positioning System
EMI	=	electromagnetic interference
EQT	=	Army Environmental Quality Technology Program
ERDC	=	U.S. Army Corps of Engineers Engineering, Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
GPR	=	ground-penetrating radar
GPS	=	Global Positioning System
GX	=	Geosoft executable
HH	=	handheld
IMU	=	International Measurement Unit
JPG	=	Jefferson Proving Ground
MS	=	Microsoft
MTADS	=	Multi-Sensor Towed Array Detection System
NMEA	=	National Maritime Electronics Association
NRL	=	Naval Research Laboratory
PDOP	=	precision dilution of precision
POC	=	point of contact
ppm	=	parts per million
PVC	=	polyvinyl chloride
QA	=	quality assurance
QC	=	quality control
ROC	=	receiver-operating characteristic
RTK	=	real-time kinematic
SAR	=	synthetic-aperture radar
SERDP	=	Strategic Environmental Research and Development Program
UTC	=	universal time coordinated
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

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